The Massachusetts Estuaries Project

Embayment Restoration and Guidance for Implementation Strategies

2003

Massachusetts Department
of
Environmental Protection

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INTRODUCTION

The **estuaries** and **embayments** of southeastern Massachusetts stretch from the Town of Duxbury south and include Cape Cod, Buzzards Bay, the Islands, and Mt. Hope Bay. They are **ecosystems** that provide not only recreational opportunities but also **habitat** for shellfish and sea grasses and breeding grounds for important marine fisheries.[1] Protection of these coastal water resources has increasingly become a priority for Massachusetts oceanfront communities.

Many estuaries are at risk of, or are already experiencing, degraded **water quality** and habitat due to increases in nitrogen discharges within their watersheds. With local communities dependent on a high quality of water for fishing, shellfishing, and tourism, degradation of these resources has serious economic results: reductions in property values, local commerce, and tax revenues. Given the synergy among these interests, embayment protection and restoration is of paramount importance to the Commonwealth and its coastal communities.

The Massachusetts Estuaries Project (**MEP**) began in order to address the problems caused by excess **nitrogen loading** in 89 estuaries in southeastern Massachusetts *(see Appendix C for a complete listing of MEP estuaries)*. The MEP is a collaborative effort among coastal communities, the Department of Environmental Protection (**DEP**), the School of Marine Science and Technology **(SMAST**) at the University of Massachusetts in Dartmouth, the US Environmental Protection Agency (**EPA**), the Executive Office of Environmental Affairs (**EOEA**), and the Cape Cod Commission.

The MEP will provide technical data on sources of nitrogen and the maximum amount of nitrogen (**nitrogen threshold**) that each estuary can tolerate without adversely changing its character and use. In other words, the MEP will set the target to be achieved in order to protect and restore the health of estuaries.

There are a variety of pathways that can be taken to reach the final target of a healthy estuary. The challenge for coastal communities will be to determine which pathways are appropriate in their particular watersheds. Specific tasks will include assessing **nutrient** sources, developing an integrated approach to nutrient planning and management, and implementing a plan to avoid continued degradation of estuarine systems.

MEP communities will participate in these tasks in several important ways. They will be asked to contribute approximately 40% of the overall cost of assessment of estuaries. They will need to establish local groups of officials and citizens to interface with SMAST and DEP staff throughout the project, and they may need to assist with filling gaps in data on estuaries. Eventually, communities will take the lead in finalizing and carrying out their implementation plan for nitrogen reduction. Fortunately, many MEP communities are already aware of the impact of nitrogen loading and are taking steps

[1] Estuaries are areas formed when the sea extends inland and meets the mouth of a river or stream. Embayments are the bodies of water beyond the mouth of rivers or streams, partially enclosed by land but with wide openings to larger bays or the ocean. These two terms are used interchangeably in this document.

to address it. Citizen monitoring groups, regional planning and environmental organizations, and local agencies, e.g., Boards of Health (BoH)and Departments of Public Works (DPW), will bring to the table important planning, funding, and regulatory capabilities.

To assist in addressing this challenge, DEP will provide communities with information, tools, and regulatory input. This Guidance is the first of the tools designed to assist communities in the implementation phase of the MEP. It is an introduction for local officials and community members to the issue of excess nitrogen loading and the technical and management approaches available to restore the health of estuaries and embayments. The Guidance presents a menu of traditional and innovative strategies available to communities as they manage nitrogen and coastal water quality issues. Readers should keep in mind that not all the options described here will be necessary, or even appropriate, for every situation.

The Executive Summary on the following pages is a very condensed summary of topics covered in the Guidance. The remaining chapters of the full Guidance are organized as follows:

Background: Nutrient loading, sources of nitrogen loading, establishing nitrogen thresholds, and the state and federal regulatory framework for nitrogen management.

Approaches: Technology and management approaches to address sources of nitrogen loading. Additional resources and relevant state and federal regulations are listed at the end of each topic. Regulatory citations are intended to alert readers to regulations that should be consulted before a particular approach is adopted, rather than as notice that particular permits are required. The additional resources and all state and federal regulations listed throughout the Guidance are compiled in Appendix B. Most of these publications are available through the Internet. Official copies of DEP regulations are available at the Massachusetts State Bookstore.

Appendices: In order to keep the body of the Guidance to a manageable size, a great deal of information has been put into Appendices. Appendix A is a glossary of terms and acronyms; those included are printed in bold type the first time they appear in the text.

Massachusetts Estuaries Project (MEP) Resources and Regulations

State	
DEP	Home page for the MEP, including maps and background articles: http://www.state.ma.us/dep/smerp/smerp.htm
Bookstore	State Bookstore Room 116, State House Boston, MA 02133 617/727-2834; http://www.state.ma.us/sec/spr/spridx.htm

EXECUTIVE SUMMARY

Background

Although nutrients are essential to all organisms, excess nutrients can cause **eutrophication**, which is the uncontrolled growth of aquatic vegetation and algae. Eutrophication can cause the loss of **biodiversity.** Loss of eelgrass is often the first sign that the ecological health of an area is declining. Changes happen incrementally and by the time the losses are apparent, the damage can be quite costly and difficult to **mitigate**.

The focus of this Guidance is on excess nitrogen in marine waters. Nitrogen can enter an estuary from **point and nonpoint** sources. These sources present different challenges to nitrogen reduction efforts. Pollution from point sources has been greatly reduced through federal and state permitting programs. Nonpoint sources are now the primary source of pollution in the nation's watersheds.

State and federal regulations mandate that the Commonwealth and its communities address water quality impairments created by nitrogen loading. The MEP will develop nitrogen thresholds for MEP embayments and provide the information necessary to ensure that nitrogen reduction efforts are consistent with federal and state requirements. The major regulatory programs associated with the MEP are the Massachusetts Water Quality Standards for **surface water** and **ground waters** and the federal **Clean Water Act (CWA)**.

The **Total Maximum Daily Load (TMDL)** is the primary regulatory and technical tool for addressing nitrogen loading**.** A TMDL is the upper limit of ambient nitrogen concentration that will support a healthy habitat, expressed as a concentration of nitrogen in the water column, in parts per million (ppm) or milligrams per liter (mg/L). SMAST will use a linked-model approach to calculate the nitrogen threshold for the 89 estuaries in the MEP. The technical report for each estuary will also model the impact on nitrogen concentrations resulting from increased land development, elimination of all human-caused sources of nitrogen, and improvements in tidal flushing. The technical reports will help identify the most promising nitrogen reduction approaches for each estuary.

Technical reports will be incorporated into draft TMDL reports, which are subject to public comment and review by communities, EPA, and DEP. Eventually, communities will use the TMDL report for each estuary in order to develop and implement an appropriate nitrogen reduction strategy for its protection and restoration.

Approaches to Nitrogen Reduction

This chapter discusses the menu of options for mitigation of excess nitrogen. Not all options will be appropriate for every situation. However, with input from citizens, regulatory bodies, and consultants, communities will be able to identify a mix of options that meets local conditions.

Grants and the **State Revolving Fund (SRF)** loans are available through DEP for **integrated water resources management planning,** which includes implementation of specific nitrogen reduction strategies.

Tidal Flushing

Improvements in tidal flushing can reduce nitrogen mass in an embayment by up to 20%. Three primary ways to improve tidal flushing are channel dredging, inlet alteration, and culvert design improvements.

Stormwater Control and Treatment

Most nitrogen loading to Massachusetts embayments is from wastewater. However, stormwater mitigation can be significant in places where stormwater affects local resources such as shellfish beds or public beaches. Most nitrogen in stormwater comes from illicit interconnections between stormwater and sanitary drains, **combined sewer overflows (CSOs)**, failing septic systems, and fertilizer runoff. Source control and pollution prevention, CSO **remediation**, and treatment are all options that need to be considered in addressing nitrogen pollution from stormwater.

CSOs are regulated as point sources and require a **National Pollutant Discharge Elimination System (NPDES)** permit under the federal Clean Water Act and state Surface Water Discharge Permit Program. CSOs in the MEP communities of Fall River, New Bedford, and Taunton are regulated under these programs. Both DEP and EPA regulate stormwater discharges in Massachusetts. DEP's requirements are specified in its Stormwater Management Policy, which requires certain new developments and redevelopments to implement stormwater source controls, provide treatment and **recharge**, and reduce flooding impacts. EPA requirements are specified in the NPDES regulations, which apply to both wastewater and stormwater point source discharges.

Attenuation via Wetlands and Ponds

Wetlands and ponds improve the quality of water that passes through them by means of natural physical, biological and chemical processes. Although **natural attenuation** can reduce the impact of nitrogen on an estuary, it cannot be used as a wastewater treatment method. It is appropriate only where discharges have already been treated to very high water quality standards and where it will not cause a negative impact on the habitat of the wetlands or pond.

Constructed wetlands may be designed to treat wastewater and to use treated wastewater to restore wetland habitat. The Massachusetts Wetlands Restoration Program (MWRP) is a program within the Massachusetts EOEA that supports voluntary efforts to restore the Commonwealth's wetlands and aquatic ecosystems.

Wastewater

Wastewater can make up to 80% of the annual nitrogen load in some watersheds, and is the most expensive source of nitrogen loading to treat. Wastewater treatment ranges from **on-site treatment and disposal systems** for individual properties to large municipal treatment plants and sewers.

On-site systems serve homes and other small facilities with a **sewage** flow of less than 10,000 **gpd**. Conventional on-site systems do not remove significant amounts of nitrogen. Many **innovative/alternative (I/A)** on-site systems have been designed to remove nitrogen using **biological denitrification,** but require more sophisticated management and maintenance than conventional systems. **Cluster systems** are on-site systems configured to serve more than one residence or facility. They can use either conventional or innovative/alternative technologies, and improve system performance due to more uniform flow.

Community treatment plants usually treat 10,000 to 150,000 gpd. They are appropriate for areas where a high degree of nitrogen removal is required. DEP is updating its *Guidelines for the Design, Construction, Operation and Maintenance of Small Sewage Treatment Facilities with Land Disposal*, in order to reflect improvements in technology and new DEP policies.

Municipal treatment plants can discharge up to several million gallons of treated **effluent** either to ground or surface water. Large plants with advanced nitrogen treatment are able to meet the most stringent treatment standards, down to as low as 2-3 mg/L nitrogen. Large treatment plants raise complex issues of planning, design, cost, and siting, and require active community participation in their planning and construction.

Water Conservation and Water Reuse

Water conservation can improve the health of estuaries by ensuring increased ground and surface water flow. The use of reclaimed water for situations that do not require **potable** water quality can reduce the need to develop new water supplies and can provide cost-effective disposal in certain situations. DEP requires a ground water discharge permit for reuse, and has established rigorous reuse standards in order to protect public health.

Management Districts

Management districts are legal, geographic entities that carry out environmental work such as funding and building infrastructure improvements, managing infrastructure or programs, or providing other environmental protection services. Districts provide benefits from their focus, flexibility, and targeted funding mechanisms. Management districts have only recently been used in Massachusetts to manage non-traditional environmental services, such as management of on-site treatment systems, decentralized sewers, and stormwater control and treatment plans. Massachusetts law provides three mechanisms to establish districts: general state law, special acts of the Legislature, and municipal home rule authority (bylaws and regulations).

Land Use Planning and Controls

Land development has negative impacts on nutrient loading by increasing human population growth and reducing the ability of the land to naturally remediate nitrogen loading. Through smart growth policies, open space acquisition, and zoning tools, land use planning seeks to influence the amount, rate, location, and character of growth in order to maintain a community's long-term sustainability.

Nutrient Trading

Nutrient trading is a regulatory tool that allows pollutant sources to reallocate responsibilities for pollution reduction among themselves and to fund the most cost-effective reduction methods in order to meet regulatory requirements. EPA encourages watershed-based **effluent trading**, and has published documents to help states and communities use them appropriately. Existing Massachusetts regulations to not expressly authorize **nitrogen trading**, although DEP encourages communities to explore this avenue in developing their implementation plans for nitrogen reduction.

BACKGROUND

Nutrient Loading, Eutrophication, and Habitat Loss

Nutrients are essential for the survival of all living organisms. However, excess nutrients in fresh and marine waters can cause uncontrolled growth of aquatic vegetation and algae, a process known as eutrophication. When this happens, water clarity decreases and oxygen levels essential for marine life can drop dramatically, causing fish and other aquatic animals to abandon the habitat or even die.

In marine ecosystems, the nutrient of most concern is nitrogen. In fresh water, the nutrient of most concern is phosphorous, meaning that fresh water can absorb moderate amounts of nitrogen without inducing **algae blooms,** just as marine waters can absorb moderate amounts of phosphorus without altering water or habitat quality. Although phosphorus is a concern in some inland waters of MEP communities and in many other inland areas of Massachusetts, the focus of the MEP and this Guidance is nitrogen.

Eutrophication is a process that occurs naturally and gradually over a period of tens or hundreds of years. However, human-caused or **anthropogenic** sources of nitrogen may be introduced into ecosystems at an accelerated rate that cannot be easily assimilated; the result is a phenomenon known as **cultural eutrophication.** In both marine and freshwater systems, cultural eutrophication results in degraded water quality, adverse impacts to ecosystems, and limits on the use of water resources.

Discussion of the impact of eutrophication on embayments often focuses on measures of water quality, for example, high nitrogen levels and low dissolved oxygen. However, a primary concern is the negative impact on habitat that results from water quality degradation. Habitat quality relates to the amount and variety of species that can inhabit an ecosystem. The greater the biodiversity, the more robust the system and the better able it is to withstand acute upsets in local surroundings.

Ecosystems stressed by high nitrogen loadings often have only a limited variety of plants and animals, and will frequently experience an increase in **invasive species** compared to native species. As a result of excess nitrogen, what would be considered a minor upset in a healthy ecosystem may have a major impact, ranging from nuisance algae blooms to serious fish kills.

Before an ecosystem becomes totally degraded, much of its ecological and economic value has been lost. In many coastal systems, the beginning of this change is the loss of eelgrass. Eelgrass provides habitat for shellfish and finfish spawning, and promotes stability of bottom sediments. As eelgrass is lost due to nitrogen over-enrichment, shellfish and finfish habitat is lost, and sediments are circulated more easily through the **water column**. Resulting increases in **turbidity** limit the distribution and variety of aquatic plants, which in turn allows invasive nuisance species to crowd out native plant species and proliferate. The decomposition of the increased **biomass** depletes the oxygen in the water column and reduces water clarity, which in turn may result in fish kills.

There is not necessarily a specific event that suddenly causes an unhealthy habitat. More likely there is a gradual downward spiral that develops over a period of years. The danger is that incremental changes resulting from degraded water quality may not be immediately noticeable. By the time changes are apparent, they may be very difficult, expensive, and time-consuming to reverse. With an informed understanding of the sensitivity of estuarine waters and the impact of excess nitrogen, as well as knowledge of appropriate methods to mitigate them, effective steps can be taken to protect embayments and estuarine systems. Preventing further degradation of relatively healthy embayments is almost certainly less expensive and disruptive than attempting to restore those already impaired by nitrogen loading.

Sources of Nitrogen Loading: Point and Nonpoint Sources

Nitrogen enters estuaries from a wide variety of sources, each of them presenting different challenges to a program of nutrient management. Sources are typically categorized as point or nonpoint sources. Although the distinction between point and nonpoint can differ depending on state or federal regulations and the path of a discharge, we have categorized them as follows for purposes of the MEP.

Point sources discharge from a specific geographical point, often as a discharge from a pipe or conveyance. Since passage of the federal Clean Water Act in 1972, pollution from point sources has been greatly reduced through a combination of federal and state permitting programs. Point sources include the following:

- Outflows from a wastewater treatment plant to a river, bay, or ground water.
- Indirect discharges from industrial or commercial connections to a sewer.
- Discharges from stormwater collection and treatment systems or combined sewers that are piped to a river or embayment.

Nonpoint sources discharge nitrogen across a less defined geographic area and often cannot be traced to a single physical location. They are now the primary source of pollution in the nation's watersheds, and only recently have regulatory programs been developed to address them. Nonpoint sources include the following:

- On-site wastewater treatment systems (Title 5 systems).
- Stormwater: runoff that washes into estuaries from rain or snow.
- Lawns: nitrogen leaching into groundwater or runoff from excessive use of fertilizers on lawns.
- Agricultural runoff from improperly managed animal wastes or fertilizers.
- Runoff from road and building construction.
- Natural **deposition**, either as precipitation (wet) or ash (dry).

Establishing Nitrogen Thresholds and Reducing Nitrogen Loads

State and federal regulations mandate that the Commonwealth and its communities address water quality impairments created by nitrogen loading. Operating under this broad regulatory umbrella, the MEP will develop nitrogen thresholds for southeastern Massachusetts coastal embayments and provide the information necessary to ensure that nitrogen reduction efforts are consistent with both federal and state requirements. The major regulatory programs associated with the MEP are the Massachusetts Water Quality Standards for surface water and ground waters and the federal Clean Water Act.

Massachusetts Surface Water Quality Standards

The Massachusetts Surface Water Quality Standards establish quantitative and qualitative standards for the protection of surface waters in inland and coastal areas. The MEP is charged with developing critical nitrogen thresholds that will meet these water quality standards.

The anti-degradation provisions in the standards require that water quality goals be based on the designated uses for water bodies, and that the water quality necessary to sustain these uses be maintained for all surface waters in the Commonwealth. The standards further require that certain high-quality and significant resource waters be protected beyond the minimum national criteria, especially where their character and value cannot be adequately described or protected by traditional water quality criteria. Federal and state statutes also require the protection of all navigable waters, which includes coastal embayments and estuaries.

The standards also address eutrophication. Regulations prohibit new point source discharges of nutrients to lakes and ponds, and require the use of highest and best practical treatment to control nutrients in existing point source discharges. Nutrient control of nonpoint sources is required through **best management practices (BMPs).** In addition, the standards require that nutrients not exceed a nitrogen threshold developed for a specific estuary.

The standards define three classes - SA, SB, and SC - of coastal and marine waters, based upon the water quality goal for each class ("S" stands for Saltwater or Saline). Standards are both quantitative and qualitative, and at a minimum require that these waters be protected as habitat for fish and other aquatic life, for wildlife, and for swimming and boating. They must also possess "good aesthetic value." Both the quantitative nutrient standards and the qualitative standards for aesthetics, nutrients, water chemistry, bottom pollution, and alteration must be considered in addressing nitrogen loadings. Appendix D provides detailed standards for the parameters that define SA, SB, and SC waters.

Quantitative water quality standards are typically measured in concentration levels of specific **pollutants**, and are supported by scientific research and consensus. For example, public health concerns are the rationale for quantitative water quality measures of bacteria and **nitrates** in drinking water supplies. In the Surface Water Quality Standards, both quantitative and qualitative standards are used

as indicators of ecological health and habitat quality. Quantitative standards include dissolved oxygen, pH, and temperature.

Qualitative standards such as aesthetics, taste, odor, color, turbidity, and floating or suspended solids are also important in measuring ecological health and habitat quality. They can be used to determine if the water body meets its designated uses such as swimming, fishing, and healthy aquatic habitat. Many qualitative measures are more subjective and in some cases have not have been fully developed. One goal of the MEP is to establish appropriate criteria or thresholds for standardized indicators of ecological health in coastal waters.

Massachusetts Ground Water Quality Standards

Ground water is defined as all water that exists beneath the land surface in soils or geologic formations, specifically that part of the subsurface water in the saturated zone.

Ground water is vitally important to the health of MEP communities for several reasons. First, it is the main, and in some cases the only source of potable water for many communities in southeastern Massachusetts. Second, the ground and ground water is the mechanism used to dispose of pollutants from wastewater treatment works, including on-site wastewater treatment systems. Wastewater disposal facilities need to be located so as not to degrade either the ground water itself or **down gradient** surface waters. Nutrients transported in the ground water from wastewater treatment works could both adversely affect the ground water as a source of drinking water and degrade the quality of surface waters.

The goal of the Massachusetts Ground Water Quality Standards is to control the discharge of pollutants to ground waters to ensure that they are protected to their highest

potential use. The Massachusetts Ground Water Quality Standards follow the same concepts as the Surface Water Quality Standards. They classify the uses for the ground waters of the Commonwealth and specify the water quality criteria necessary to sustain these uses.

All ground waters are assigned to one of three classes (I, II, and III) based upon the most sensitive use for which the ground water is to be maintained. With few exceptions, Massachusetts ground waters are designated as Class I, meaning that they are a source for drinking water or could be used as one in the future. Appendix E outlines the standards for the three ground water classes.

Any subsurface discharge of treated wastewater exceeding 10,000 gpd requires a discharge permit establishing the conditions necessary to comply with ground water standards. Each Ground Water Discharge Permit contains a set of effluent discharge limits that comply with the Standards and are meant to protect all classified waters of the Commonwealth, including surface waters. Ground water permits require a series of ground water monitoring wells and a sampling schedule to determine if the standards are met. A typical permit will contain an effluent total nitrogen limit of 10 mg/L in order to protect the ground water as a potential potable water supply. As our knowledge of the sensitivity of receiving waters increases, it is likely that a more stringent ground water effluent standard will be required on a case-by-case basis to protect the quality of ground waters and surface waters, including estuaries and embayments.

Federal Clean Water Act and Total Maximum Daily Load (TMDLs)

The Federal Clean Water Act of 1972 provides a framework for the Commonwealth's plan to restore its estuaries to the level required by state water quality standards. Section 303(d) of the Clean Water Act requires that states develop lists of impaired waters, i.e., water bodies (both freshwater and marine) that do not meet the uses designated in each state's water quality standards. Impairment may be caused by many different pollutants, including but not limited to nitrogen, phosphorus, bacteria, or metals. The MEP will address bacterial contamination for selected estuaries where shellfish and recreational resources have been compromised. However, the major thrust of the MEP and the major focus of this Guidance is nitrogen reduction.

A state's list of impaired waters is known as its 303(d) list. The Clean Water Act requires states and communities to take action to restore their impaired waters, a process which begins with assessing the condition of impaired waters, determining the causes of impairment, and specifying the maximum amount of pollution that the waterbody can receive and still meet state standards.

The regulatory and technical tool for this work is the Total Maximum Daily Load (TMDL). A TMDL for an estuary or embayment is its nitrogen threshold (also known as a nitrogen limit), which is the upper limit of ambient nitrogen concentration that will support a healthy habitat. The threshold is expressed as a concentration of nitrogen in parts per million (**ppm**) or milligrams per liter (**mg/L**) in the water column. SMAST uses a linked-model approach to calculate these numbers, incorporating hydrodynamics, water quality modeling, and land use modeling. See Appendix F for a detailed discussion of the linked-model approach and how nitrogen thresholds are calculated.

The technical evaluation of each estuary done by the MEP team from SMAST will include four linked-modeling scenarios:

- The nitrogen threshold that will support a healthy ecosystem and appropriate uses of water resources;
- The predicted nitrogen concentrations in the estuary assuming a build-out scenario based on current local zoning regulations;
- Potential water quality improvements resulting from the removal of anthropogenic sources of nitrogen from contributing watersheds; and
- Potential water quality improvements resulting from physical improvements to increase flushing, such as dredging, inlet alterations, and culvert improvements.

The nitrogen threshold set in the TMDL for each estuary will be incorporated into a draft TMDL Report by DEP. Each draft TMDL Report will include some possible nitrogen reduction strategies for communities to consider in the implementation phase. The draft TMDL Reports will be subject to public comment and input before being finalized and accepted by communities, EPA, and DEP. Because the

MEP is evaluating watersheds, the TMDL Reports will involve both watersheds contained entirely within a single community and those encompassing more than one community. TMDLs will be released for individual estuaries over the next several years as embayment nutrient loads are established. The first ones are scheduled for release in 2003.

The detailed planning and implementation phase undertaken by communities will be based on the nitrogen threshold and potential nitrogen reductions provided in the TMDL Report for each estuary. As noted earlier, the primary goal of this Guidance is to introduce communities to the variety of strategies to consider in crafting an implementation plan. During the implementation phase, communities will be able to request additional modeling work in order to determine the nitrogen reductions from scenarios not covered in the original technical evaluations. Following the integrated water resources management planning process described in the chapter "Approaches to Nitrogen Reduction" of this Guidance, communities will plan and implement specific capital improvements and nitrogen management strategies.

Other State and Federal Regulatory Programs

In addition to the federal Clean Water Act and the state Water Quality Standards for surface water and ground water quality, a number of other regulatory programs will impact nitrogen reduction efforts. In the chapter "Approaches to Nitrogen Reduction," the relevant state and federal regulations are referenced in the description of each nitrogen reduction option. Appendix B compiles in one place all the resources and regulatory programs listed throughout the document.

Regulating Nitrogen Loads, Resources and Regulations

Federal EPA	Total Maximum Daily Load Program: http://www.epa.gov/OWOW/tmdl/
	National Pollutant Discharge Elimination System (NPDES) Regulations, Clean Water Act, § 402: http://cfpub1.epa.gov/npdes/cwa.cfm?program_id=6 http://www.epa.gov/region01/npdes http://cfpub.epa.gov/npdes/
State DEP	Surface Water Quality Standards, 314 **CMR** 4.00: http://www.state.ma.us/dep/bwp/iww/files/314004.pdf
	Surface Water Discharge Permit Program, 314 CMR 3.00: http://www.state.ma.us/dep/bwp/iww/files/314cmr3.htm
	Ground Water Quality Standards 314 CMR 6.00: http://www.state.ma.us/dep/bwp/iww/files/314006.pdf
	Ground Water Discharge Permit Program, 314 CMR 5.00: http://www.state.ma.us/dep/bwp/iww/files/314005.pdf

APPROACHES TO NITROGEN REDUCTION

Effective strategies for nitrogen reduction will require a mix of tools ranging from infrastructure changes, which typically involve traditional engineering design and construction, to more recently developed management programs and institutional changes. The following pages are a primer of basic information on the broad menu of options for managing nitrogen loads. Options are presented in the following categories:

- Tidal flushing
- Stormwater control and treatment
- Attenuation via wetlands and ponds
- Wastewater treatment
- Water conservation and reuse
- Management districts
- Land use planning and controls
- Nutrient trading

Historically, wastewater treatment has been the primary approach used for nitrogen reduction, and it will continue to be important. At the same time, DEP encourages communities to think beyond the traditional engineering approaches to consider all options and combinations.

Not all of the options presented here will be applicable to the challenges in a particular estuary. The technical evaluations coming out of SMAST will help identify the most promising approaches.

In addition, many MEP communities have developed programs to assist in nitrogen management. Government agencies including Boards of Health and Departments of Public Works, regional commissions, and citizen groups are knowledgeable about planning and funding strategies to implement coastal water quality improvements. By evaluating various options with input from citizens, regulatory bodies, and consultants, communities can craft an implementation strategy to manage nitrogen loads in their watersheds and estuaries.

Integrated Water Resources Management Planning and Funding Sources

A successful nitrogen management strategy will be based on the concepts of integrated water resources management planning. Integrated water resources management planning includes consideration of the full range of water resources needed to support ecological health as well as meet human needs. It requires extensive outreach and education in order to develop an integrated strategy that has community input and support for the final mix of solutions. Typically, the result of this planning process is definition of the scope and nature of wastewater problems and development of appropriate wastewater solutions. At the same time, DEP recognizes that long-term viable solutions to wastewater problems must consider many factors, including water supplies and demands of the community; streamflow and water quality considerations; ground water as a resource for existing and potential drinking water and a source of base flow to rivers and streams; stormwater management; and the long term land use and economic development goals of a community and the watershed within which it is located.

In the past, communities carried out integrated water resources management planning through a Comprehensive Wastewater Management Plan (CWMP). However, DEP is promoting a more holistic approach and is revising the current guidelines to reflect a watershed-based planning process. National trends suggest that watershed-based permitting will help achieve greater levels of resource protection rather that permitting individual facilities. The current guidelines are available on the DEP Web site, but communities that will be initiating water resources management planning should consult with DEP to develop a scope that reflects the more holistic approach.

DEP grant and loan programs provide opportunities to assist communities in integrated water resources management planning, including implementation of specific nitrogen reduction strategies. Programs include the Massachusetts **Clean Water State Revolving Fund Program (CWSRF)** and federal grant programs**.**

Massachusetts Clean Water State Revolving Fund Program (CWSRF). The CWSRF was established to provide a low-cost funding mechanism to assist communities in complying with federal and state water quality requirements. Each year DEP solicits projects from municipalities and wastewater districts to be considered for subsidized loans. The current subsidy is provided via a 2% interest loan. In recent years the program has financed 50-70 projects annually.

CWSRF money is available for planning and construction of facilities for wastewater treatment facilities (new and upgrades), on-site treatment upgrades, stormwater control and treatment, nonpoint source mitigation projects, and CSO remediation. Funds may also be used for planning projects, e.g., identification of nonpoint source pollution. DEP issues an annual solicitation beginning June 1 through August 15, and develops a list of projects eligible for funding from submittals from communities.

Grant Programs. DEP awards grants in a number of areas that support the nitrogen reduction efforts of the MEP. The three major grant programs consist of federal funds from EPA.

604(b) Water Quality Management Planning. The RFP is issued each October to cities and towns, regional planning organizations, conservation districts, and interstate agencies. Nonpoint source assessment projects are priorities for this source of funds, including:

- Stormwater Best Management Practices
- Local Water Quality Protection
- Land Use Activities
- Environmental Awareness, Activities, and Concerns
- Water Quality Assessment
- Water Supply/Quality Source Protection Planning
- Water Supply Development Planning
- Wetlands Assessment and Restoration Planning

104(b)(3) Wetlands and Water Quality. The RFP is issued in January each year to state agencies in EOEA. Other organizations can participate with EOEA agencies in projects. 104(b)(3) goals that are compatible with goals of MEP include the following:

- Control of point and nonpoint discharges to surface and ground water
- Resources to ensure no net loss of wetlands
- Minimizing degradation of wetlands by stormwater runoff
- Minimizing unpermitted filling or alteration of wetlands
- Discouraging projects in or next to wetlands

319 Nonpoint Sources. Proposals are solicited each February from all Massachusetts public or private organizations. Grants fund implementation projects that address the prevention, control, and abatement of nonpoint source pollution.

DEP's web site provides additional detail on DEP's grant and loan programs. Since priorities, schedules, and requirements may change over time, we encourage readers to investigate DEP's web site for the latest available information. DEP staff are also available to consult with communities on applicability of the programs to local needs.

Approaches to Nitrogen Reduction, Resources and Regulations

State	
DEP	Comprehensive Wastewater Management Planning Current guidance (1996): http://www.state.ma.us/dep/brp/mf/files/fpintro.htm New Guidance for Integrated Water Resources Management Planning is under development. Contact the Department for more information. Grant and Loan Programs: Opportunities for Watershed Protection, Planning and Implementation, updated November 2002: http://www.state.ma.us/dep/brp/mf/files/glprgm.pdf Clean Water State Revolving Loan Fund (CWSRF): http://www.state.ma.us/dep/brp/mf/cwsrf.htm

Tidal Flushing

Tidal flushing is the flow of water in and out of an estuary due to rising and falling tides. Determining **flushing rates**, or **residence times**, is an important component of the linked-model approach used in the MEP.

The residence time is the average time required for a particle of water to migrate out of the estuary from a given point in it. **System residence time** refers to the average time for water to migrate through the entire system. **Local residence time** is the average time for water to migrate from a point in a **sub-embayment** to a point outside the sub-embayment.

Residence times provide a rough qualitative estimate of water quality. Lower residence times indicate more efficient flushing and therefore may indicate higher water quality. Conversely, higher residence times indicate less efficient flushing and potentially lower water quality. However, this rule of thumb must be tempered with an understanding of the dynamics of the estuary. For example, efficient flushing will not promote high water quality if a nutrient is loaded into an estuary faster than it can be flushed out.

The dynamics of tidal exchange and flushing are complex and require a model to simulate tidal flows and dynamics. The linked model used in the MEP is able to evaluate the hydrodynamic properties of an estuary or embayment system in order to determine if enhanced flushing can result in higher water quality. If so, relatively low cost measures may yield significant improvements in water quality. For example, improvements in flushing could reduce the nitrogen mass in an embayment by 20%. Communities will need to carry out an evaluation of these alternatives as part of the implementation phase to determine the most cost-effective approach. The evaluation will also assess the short- and long-term environmental impacts to the wetland systems and tidal flows.

There are three primary ways of improving tidal flushing: channel dredging, inlet alteration, and culvert design or improvements. The same federal and state regulations apply to these three approaches, and are listed in the table below rather than in individual sections.

Tidal Flushing, Resources and Regulations

Federal	
ACOE	Army Corps of Engineers (ACOE) Permit Authorization under Section 10, Rivers and Harbors Act: http://www.spk.usace.army.mil/cespk-co/regulatory/regs/start.html
State	
DEP	Waterways License, 310 CMR 9.00, Chapter 91: http://www.state.ma.us/dep/brp/waterway/ch91regs.htm
	Current Dredging Regulations: 401 Water Quality Certification, 314 CMR 9.00 (Contact DEP for updated interim procedures on dredging and management of dredged sediments): http://www.state.ma.us/dep/bwp/iww/files/314009.pdf
	Notice of Intent, Wetlands Protection Act, 310 CMR 10.00, Section 10.05, #4: http://www.state.ma.us/dep/brp/ww/files/310cmr10.pdf
MEPA	Massachusetts Environmental Policy Act: MEPA Certificate, 301 CMR 11.00: http://www.state.ma.us/envir/mepa/thirdlevelpages/meparegulations/301cmr11.pdf
CZM	Coastal Zone Management (CZM) Federal Consistency Review, 301 CMR 21.00: Coastal Zone Management Program: Federal Consistency Review Procedures http://www.state.ma.us/czm/fcr.htm

Channel Dredging

As navigable channels slowly fill in through natural or induced sedimentation, tidal flushing may be restricted. Where feasible, dredging can improve flushing rates. This option may be limited to areas below the low tide line, since dredging between the **mean low** and **mean high water** shorelines may impact shellfish growing areas. Dredging can also disrupt eelgrass habitat. In addition, sediments need to be sampled to determine if dredging will disturb any contaminated material. Dredging generally must be repeated periodically in order to be effective. A community's evaluation of this approach must examine a range of years in order to compare the environmental and economic costs of repeated dredging and disposal of sediment.

Inlet Alteration

Embayment systems are not static. Natural coastal processes will alter shoreline profiles over decades or in some instances even from year to year. These changes can alter inlets to embayments and affect flushing. If the present configuration of an inlet restricts flushing, alteration of the inlet may significantly improve water quality in the same way as described in the channel dredging section. Other potential impacts that need to be analyzed for this option are **salinity**, temperature, turbidity, and erosion patterns. **Sediments** need to be sampled to determine if any contaminated material will be disturbed.

Culvert Design and Improvements

In certain instances culverts or bridge openings can restrict tidal exchange. Increasing culvert or bridge opening size can improve tidal exchange by increasing tidal range. Modeling different culvert sizes can determine optimal configurations. Culvert alteration will result in changes in tidal height, which in turn must be evaluated for potential impacts on surrounding marshlands. If tidal height is too high, greater portions of impacted marshes may be inundated with salt water and the marsh system altered.

Stormwater Control and Treatment

Stormwater transports nutrients, pathogens and bacteria, metals, suspended solids, and other constituents into embayments via point sources (e.g., stormwater outfall pipes) and nonpoint sources (e.g., runoff from fertilizer). Nitrogen compounds are present in the stormwater and eventually discharge into embayments. Impervious surfaces may accelerate the input of nitrogen into tidal and inland waters.

Nitrogen compounds flushed into estuaries by stormwater come both from natural precipitation (rain and snow) and from anthropogenic sources. Sources flushed from the natural background are part of the **nitrogen cycle**, in which plant matter decays, nutrients are absorbed into the ground, and are then taken up by new plant growth. Anthropogenic sources carried by stormwater include fertilizers (from agricultural, suburban, and urban areas), septic system leachate, farm animal and pet waste, and atmospheric deposition and precipitation of nitrogen compounds from power plants and automobiles. Human activities that attract a concentration of birds can also cause nitrogen loading via stormwater.

Both DEP and EPA regulate stormwater discharges in Massachusetts. DEP's requirements are specified in its Stormwater Management Policy, an umbrella policy adopted under multiple DEP regulations, including the Wetlands Protection regulations. The Stormwater Management Policy requires certain new developments and redevelopments to implement stormwater source controls, provide treatment, recharge, and reduce flooding impacts. EPA's requirements are specified in the NPDES regulations, which apply to both wastewater and stormwater point source discharges. The NPDES stormwater requirements apply to industry (including all local DPWs), government agencies (e.g., the Massachusetts Highway Department), designated municipalities (72% of Massachusetts towns have been designated), and land disturbances of one acre or more (e.g., construction activities).

Because the vast majority of nitrogen loading to embayments in Massachusetts is from wastewater, reductions in nitrogen from source control of stormwater, remediation of combined sewer overflows (CSOs), control of agricultural land uses, and stormwater treatment may appear to be a relatively small portion of the total nitrogen load in a watershed. However, stormwater mitigation may be necessary in areas where pollution from stormwater affects local resources such as shellfish growing areas or public swimming beaches.

The documents listed in the table below apply generally to stormwater control and treatment strategies. Regulations and resources for specific stormwater issues are listed in each section.

General Stormwater Control and Treatment, Resources and Regulations

Federal	
EPA	National Pollutant Discharge Elimination System (NPDES) Regulations, Clean Water Act, Section 402: http://cfpub1.epa.gov/npdes/cwa.cfm?program_id=6 http://www.epa.gov/region01/npdes/ http://cfpub1.epa.gov/npdes/stormwater/swphase2.cfm?program_id=6
State	
DEP	Stormwater Management: Policy (Vol I) and Technical Handbook (Vol II), 1997. http://www.state.ma.us/dep/brp/stormwtr/stormpub.htm

Source Control and Pollution Prevention

Eliminating sources of nitrogen in stormwater is generally more cost-effective than end-of-pipe treatment. Monitoring both dry and wet weather flow at stormwater outlets is usually necessary to identify point sources of nitrogen. A land use analysis is usually necessary to identify nonpoint sources.

The highest fraction of nitrogen in stormwater is typically from illicit interconnections between stormwater and sanitary drains, CSOs, failing septic systems, and fertilizer runoff. CSO reduction efforts under the NPDES General Permit for Phase II Stormwater will address many of these sources. Communities will be required to locate and eliminate any illicit interconnections between the sanitary and stormwater collection systems. Failing on-site treatment systems that may be impacting stormwater should be identified and brought into compliance with current standards. Cracked or loosely butted stormwater pipes, which allow entry of subsurface sanitary leachate, should also be considered for repair.

Although fertilizer application rates vary with different types of land use, some studies have indicated that runoff and **infiltration** from lawns can comprise more than 10% of the yearly nitrogen load to inland and tidal embayments. Reducing use of fertilizers by homeowners, farmers, or golf-course owners requires an intensive, long-term public outreach/education campaign. Small amounts of nitrogen in stormwater are typically due to pet wastes and other dry deposition on impervious surfaces such as parking lots. Programs to reduce pet waste need to be based on large-scale outreach and education, since private citizens are key to reducing this type of nutrient pollution.

Combined Sewer Overflow (CSO) Remediation

Combined sewer overflows result from a flow of stormwater to a sanitary sewer, or from an illegal connection of sanitary flow to a storm sewer. Eliminating or reducing CSOs by separating sanitary and stormwater flows, or by other means such as CSO storage and treatment, can play a significant role in reducing bacterial and nutrient loading to specific segments of embayments and other waterways. It has been a long-standing goal of the EPA and DEP to eliminate or reduce CSOs. DEP's *Policy for the Abatement of Pollution from Combined Sewer Overflows* provides detailed information on the regulatory requirements for CSO control.

The CSO planning process provides for an assessment of CSO control alternative, their costs, and water quality benefits. Plans for controlling nitrogen loading should consider the technical information in these CSO plans. Some CSO remediation strategies, such as separating the flows of wastewater and stormwater, may result in increased flow and higher nitrogen loads to the wastewater treatment plant. For this reason, eliminating or reducing CSOs should be evaluated in conjunction with treatment plant upgrades that may be necessary to treat increased nitrogen loading at the plant.

Permitting to eliminate or reduce the number of times a CSO discharges sanitary wastes may include, but is not limited to, CSO permits, Wetlands Protection Act and regulations, and 401 Water Quality Certification. Separating sanitary and storm flows may also result in additional stormwater flows to stormwater outfalls rather than to a wastewater treatment plant. The increase in stormwater outfall discharges will need to be evaluated under a wetlands protection review to determine if peak discharge rates need to be reduced and whether or not additional treatment is necessary under the Massachusetts Stormwater Management Policy.

CSO Remediation, Resources and Regulations

State	
DEP	Stormwater Management: Policy (Vol I) and Technical Handbook (Vol II), 1997: http://www.state.ma.us/dep/brp/stormwtr/stormpub.htm 401 Water Quality Certification, 314 CMR 9.00: http://www.state.ma.us/dep/bwp/iww/files/314009.pdf Notice of Intent, Wetlands Protection Act, 310 CMR 10.00: http://www.state.ma.us/dep/brp/ww/files/310cmr10.pdf Policy for Abatement of Pollution from Combined Sewer Overflows (Under Surface Water Section): http://www.state.ma.us/dep/brp/brppols.htm

Stormwater Treatment

While end-of-pipe treatment solutions are available to reduce nutrients contained in stormwater, generally these options are more expensive than source controls and pollution prevention measures. However, treatment can be important in specific areas, if a discharge impacts areas such as shellfish growing areas or public swimming beaches.

Portions of many estuaries are designated as **critical resource areas**, in which nitrogen removal is particularly important to maintain water and habitat quality. For this reason, the Massachusetts Stormwater Management Policy requires that stormwater treatment technologies used in critical resource areas be capable of providing a higher level of treatment. See Volume II of the Massachusetts Stormwater Management Technical Handbook and Standard No. 6 of the Stormwater Management Policy for details.

Off-line treatment systems are designed to retain a standing volume of stormwater for a designated time period, in order to allow for physical settling of suspended particles and for biological and chemical treatment to occur (e.g., nutrient uptake). Off-line processes that can reduce nitrogen include constructed wetlands and filtration systems.

Many innovative stormwater treatment units operate **on-line,** by treating stormwater at a designated flow rate. Their retention times are very short. While on-line systems do reduce suspended sediments, typically they do not remove nitrogen. Innovative on-line treatment units that have been shown to be capable of removing nitrogen use filtration and biofiltration technology. The Massachusetts Strategic Envirotechnology Partnership (STEP) has evaluated the performance of some innovative stormwater treatment technologies.

Stormwater Treatment, Resources and Regulations

State	
DEP	Notice of Intent, Wetlands Protection Act, 310 CMR 10.00 (when stormwater treatment impacts areas subject to the Wetlands Protection Act): http://www.state.ma.us/dep/brp/ww/files/310cmr10.pdf
STEP	Strategic Envirotechnology Partnership (STEP) Reports and Fact Sheets on innovative stormwater treatment systems: http://www.stepsite.org/progress/reports/

Attenuation via Wetlands and Ponds

In seeking innovative ways of managing nutrients, it is important to consider the ability of natural systems to retain nitrogen in **nutrient sinks** or **attenuate** it through **biologically mediated denitrification**. Natural attenuation can be an effective option for reducing the impact of nitrogen on an estuary. However, over the long term, natural attenuation may present a risk of wetlands degradation and negative impacts on water quality and habitat. DEP has addressed this concern by prohibiting wetlands and ponds from being considered as a primary means of, or substitution for, wastewater treatment. Rather, wetlands and ponds are to be seen as polishing agents for ground water plumes from sources already treated to the highest possible standards, or for attenuating background concentrations in upstream ground water.

Natural attenuation via wetlands or ponds is appropriate only if the discharge has already been treated to Massachusetts Class I Ground Water Quality Standards and has become part of ground water flow. In addition, the concept of natural attenuation does not allow for physical alteration of wetlands or ponds associated with them. Proposals of this type fall into the realm of constructed wetlands and require full compliance with regulations in the **Wetlands Protection Act**.

In considering natural attenuation as a nitrogen reduction tool, it is critical to analyze the discharge location and the wetland's or pond's ability to assimilate nitrogen. Wetlands or ponds that currently intercept effluent plumes from on-site wastewater systems or existing treatment facilities should be priority candidates as natural attenuation tools rather than wetlands or ponds not already impacted by nitrogen in ground water.

General Wetlands and Ponds, Resources and Regulations	
Federal	
EPA	Wetlands Program, Office of Water http://www.epa.gov/owow/wetlands/
State	
DEP	Wetlands Program: http://www.state.ma.us/dep/brp/ww/rpwwhome.htm Wetlands Protection Act Regulations, 310 CMR 10.00: http://www.state.ma.us/dep/brp/ww/files/310cmr10.pdf

Wetlands

Wetlands improve the quality of water that passes through them by means of physical, biological, and chemical processes. As the water enters the wetland, it spreads out and slows down, allowing for physical settling. Soil particles, organic matter and some nutrients are filtered out, absorbed, or settled. Communities of microorganisms are able to grow on the stems and roots of plants by using the nutrients and organic material carried in the water entering the wetland, offering an ideal environment for bacteria and algae to degrade organic material and remove chemicals that originate from upstream.

The actual conversion of nitrogen in this environment is known as biologically mediated denitrification. Nitrogen enters the ground water predominantly as nitrate, which does not change to any other form of nitrogen unless the proper conditions exist for some type of conversion. Salt marsh wetlands fringing an embayment will generally be good candidates for this type of conversion: marsh peat and mud contain the right combination of organic carbon, naturally occurring denitrifying bacteria, and anoxic conditions that allow the conversion of nitrate to nitrogen gas. Nitrogen gas is an inert form of nitrogen that vents without harm to the atmosphere, where it makes up approximately 80% of the air we breathe.

If a wastewater treatment facility discharges to the ground, the treated effluent will leach to the ground water and move down gradient with it in a relatively well-defined plume. If the discharge area can be sited so that the ground water flow containing the plume is intercepted by a wetland, additional nitrogen removal may occur naturally.

Although wetland systems (and ponds) should not be used in lieu of wastewater treatment, it is possible to take advantage of their ability to attenuate nitrogen, thereby providing a buffer of protection for water quality. This may result in an overall reduction of nitrogen loading to an embayment. A hydrogeologic study must be done to evaluate hydrogeologic conditions and ground water flow, in order to ensure that the effluent plume is intercepted by the wetland system. The evaluation is also necessary to confirm that the proper conditions exist for nitrogen removal, and that other pollutants in the plume (e.g., phosphorus or BOD) will not have an adverse impact on the wetlands.

As an example, assume an existing treatment facility that discharges to the ground and a nitrogen-rich ground water plume that ultimately empties into an embayment about a mile away. A salt marsh wetlands surrounds a portion of the embayment, and it has been demonstrated that natural attenuation in the marsh removes about 20% of the nitrogen in the ground water plume before the plume enters the embayment. The treatment plant currently discharges 800,000 gallons per day (gpd) at 10 milligrams per liter (mg/L) total nitrogen. However, the MEP linked model indicates that nitrogen loading in the embayment is over the allowable threshold. The critical nitrogen limit can only be achieved by improving the discharge to 3 mg/L total nitrogen at a flow of 750,000 gpd, not accounting for the marsh attenuation. If natural attenuation in the marsh can remove an additional 20% of nitrogen, the flow from the treatment plant can be increased from 750,000 gpd to 937,500 gpd at a concentration of 3 mg/L.

Wetlands, Resources and Regulations

State	
DEP	Ground Water Quality Standards, 314 CMR 6.00: http://www.state.ma.us/dep/bwp/iww/files/314006.pdf Groundwater Discharge Permit Program, 314 CMR 5.00: http://www.state.ma.us/dep/bwp/iww/files/314005.pdf
MEPA	Massachusetts Environmental Policy Act: MEPA Certificate, 301 CMR 11.00: http://www.state.ma.us/envir/mepa/thirdlevelpages/meparegulations/301cmr11.pdf

Ponds

Ponds can act as nitrogen sinks by retaining nitrogen in the water column or in sediments. However, for the same reasons described above under wetlands systems, any consideration of a pond for nitrogen attenuation requires a thorough analysis of its assimilative capacity with regard to both nitrogen and phosphorus. The analysis should also evaluate the potential for other contaminants such as pathogens to be transported into pond water or ground water.

Ponds, Resources and Regulations

State	
DEP	Ground Water Quality Standards, 314 CMR 6.00: http://www.state.ma.us/dep/bwp/iww/files/314006.pdf Ground Water Discharge Permit Program, 314 CMR 5.00: http://www.state.ma.us/dep/bwp/iww/files/314005.pdf
MEPA	Massachusetts Environmental Policy Act: MEPA Certificate, 301 CMR 11.00: http://www.state.ma.us/envir/mepa/thirdlevelpages/meparegulations/301cmr11.pdf

Constructed Wetlands and Wetlands Restoration

The ability of vegetation, soils, and microbial activity in natural wetlands to treat wastewater has led to the idea of constructing wetlands for environmental purposes. Unlike natural wetlands, constructed wetlands may be designed both to treat wastewater and to use treated wastewater to restore wetland habitat. As of October 2000, the EPA reported that there were more than 600 active constructed wetlands in the United States.

Volume Two of DEP's Stormwater Management Handbook (referenced in the introduction to Stormwater) has detailed information on the advantages and disadvantages of constructed wetlands and guidance on their siting. Although this information is written for stormwater treatment systems, it can be adapted to wastewater treatment.

The Massachusetts Wetlands Restoration Program (MWRP) is a program within the Massachusetts EOEA that supports voluntary efforts to restore the Commonwealth's wetlands and aquatic ecosystems. MWRP inventories wetlands restoration sites and facilitates the implementation of priority restoration projects through its GROWetlands (Groups Restoring Our Wetlands) Initiative. In collaboration with its many federal, corporate, and non-profit partners, MWRP works with project sponsors to provide or obtain whatever assistance –financial, technical, monitoring or other support– is required to complete the project.

Constructed Wetlands and Wetlands Restoration, Resources and Regulations

Federal	
EPA	Guidance on Constructed Wetlands http://www.epa.gov/owow/wetlands/watersheds/cwetlands.html
State	
EOEA	Executive Office of Environmental Affairs, Massachusetts Wetlands Restoration Program: http://www.state.ma.us/envir/mwrp/index.htm

Wastewater Treatment

In a majority of watersheds in Massachusetts, wastewater is the major source of nitrogen loading; in some watersheds, it makes up approximately 80% of the annual nitrogen load. Wastewater is also the most expensive source of nitrogen loading to control. Initial community reaction to wastewater treatment options may be based on inaccurate perceptions of their effectiveness and their impact on local land use patterns.

The most common misperception about wastewater treatment is that construction of community or municipal treatment plants will lead to an increase in development. Local planning and zoning tools are available to ensure that the technological options selected to address nitrogen loading are used in accordance with local land use goals. In addition, the integrated water resources management planning process provides an objective evaluation of each technical option and public input, thereby ensuring a plan that has a much greater chance of being accepted by the community.

On-Site Treatment and Disposal Systems

Conventional on-site treatment and disposal systems are generally the least expensive and most passive means of treating sanitary sewage. They typically serve individual homes and other facilities with sewage flow of less than 10,000 gallons per day (gpd) and consist of a **septic tank**, a distribution system, and a **soil absorption system (SAS)**.

The septic tank is a pretreatment unit designed to accept raw sewage and separate solids and scum from the liquid portion of the sewage. The septic tank is designed to have a **holding time** of at least 48 hours. In addition to promoting settling of solids and separation of grease and oils, this holding time allows for some decomposition of solid and sludge. Because of the solid and scum accumulation in the tank, septic tanks need to be periodically pumped.

Septic tanks also provide a degree of **anaerobic** treatment that makes the clarified effluent more amenable to further treatment in the soil absorption system. This clarified effluent is eventually discharged from the septic tank to a distribution system. Distribution systems consist of a distribution box for gravity feed or a pump system where gravity distribution is not possible or a pressurized system is required. Whatever the configuration, the purpose of distribution systems is to deliver septic tank effluent equally across the soil absorption system.

The soil absorption system (SAS) is where the majority of treatment takes place in an on-site system. As the clarified septic tank effluent enters the SAS, it percolates through the stone of the SAS and the surrounding soil. A biological mat forms, consisting of naturally occurring bacteria that break down the impurities in the effluent. With a proper depth of unsaturated soil between the bottom of the SAS and the ground water, removal of nutrients, pathogenic organisms, and other pollutants occurs.

In Massachusetts, Title 5 of the State Environmental Code governs on-site subsurface sewage treatment and disposal systems up to 10,000 gpd. Title 5 is a state regulation; in most instances, the local Board of Health has permitting and enforcement authority. Operation and maintenance of the systems is the responsibility of the property owner.

Properly designed and sited, conventional systems do an excellent job of removing **organic pollutants**, solids, and **pathogens.** However, they do not provide significant nitrogen reduction. Based on performance data from the Massachusetts Septic System Test Center, overall nitrogen removal rates in conventional on-site systems average between 15 and 20%. The average nitrogen concentration in flows exiting a conventional system is 35 mg/L.

In addition to prescribing design standards for conventional systems, Title 5 provides for the use of **innovative/alternative (I/A)** systems that can provide enhanced treatment. Typically, these systems use **biological denitrification** to improve nitrogen removal. Removal of nitrogen is accomplished by converting the organic

nitrogen and ammonia found in raw sewage to inert nitrogen gas that harmlessly escapes to the atmosphere. While the details of unit operations may differ among the various systems, the basic principles of a biologically mediated nitrogen cycle remain the same. Most I/A systems still require septic tanks and all rely on an SAS for ultimate disposal.

Systems qualifying for a nitrogen credit under Title 5 must demonstrate an ability to reduce nitrogen to 19-25 mg/L total nitrogen, depending on acreage and flow. When operating at maximum efficiency, I/A systems can improve nitrogen reduction by even more, down to a 70% overall reduction in total nitrogen.

It must be stressed, however, that consistently high nitrogen removal rates approaching or exceeding 70% require an increased level of oversight that may be more economically and technically feasible within the context of a watershed or wastewater management district. Although Title 5 requires that I/A systems be monitored by a certified operator under a maintenance contract, the monitoring and testing frequency mandated may not be sufficient to ensure that the system is performing with optimal efficiency. National experience has shown that management districts improve the reliabilty of I/A systems and their nitrogen reduction capability by removing the burden of oversight from home and facility owners.

Title 5 has special loading limitations in areas considered particularly sensitive to nitrogen pollution. Nitrogen Sensitive Areas are defined as **Zone IIs** and **Interim Wellhead Protection Areas (IWPAs)** of public drinking water supply wells, as well as nitrogen sensitive embayments. Residential lots with new construction served by both a private drinking water well and an on-site wastewater system are also areas where nitrogen discharges to ground water are regulated. In these areas, the design flow for on-site wastewater systems is 440 gpd per acre in order to limit nitrogen levels in public and private drinking water supplies.

The planning goal for nitrogen in public drinking water supplies is 5 mg/L, and the Maximum Contamination Level (MCL) is 10 mg/L. The 440 gpd per acre loading limit from on-site systems was developed to meet a standard of 10 mg/L (total nitrogen). However, the wastewater loadings considered to be adequate for drinking water and ground water protection are not appropriate for protection of marine systems, which are typically sensitive to nitrogen contamination at one to two orders of magnitude lower than 10 mg/L.

On-Site Treatment and Disposal Systems, Resources and Regulations

Federal	
NSFC	National Small Flows Clearinghouse: http://www.nesc.wvu.edu/nsfc/
State	
DEP	Title 5 Program: http://www.state.ma.us/dep/brp/wwm/t5pubs.htm#it Title 5: Standard Requirements for … On-Site Sewage Treatment and Disposal Systems and for the Transport and Disposal of Septage, 310 CMR 15.00: http://www.state.ma.us/dep/brp/files/310cmr15.pdf Certification of Operators of Wastewater Treatment Facilities, 257 CMR 2.00: http://www.state.ma.us/dep/bwp/iww/files/257cmr2.htm

Cluster Systems

Title 5 allows shared on-site systems to serve more than one residence or facility; these are known as shared or cluster systems, and are limited to total flows of less than 10,000 gpd. Treatment technologies used in cluster systems are similar as those allowed for single on-site systems. By combining flows from several facilities, design strategies for shared systems can attenuate daily flow variations, resulting in improved and more reliable performance. As with all I/A technologies, the performance of a nitrogen-reducing cluster system is highly dependent on proper operation and maintenance, which must be carried out by a certified operator. Well-managed cluster systems using I/A technology in residential settings have been known to reduce total nitrogen below 10 mg/L.

If permitted individually under Title 5, cluster systems can only be credited for nitrogen removal down to 19-25 mg/L total nitrogen. However, it is possible to incorporate cluster systems into an overall watershed management plan regulated under a Ground Water Discharge Permit, even if flow from the system is less that 10,000 gpd. In these cases, the discharge can be credited for nitrogen removal down to 10 mg/L total nitrogen or less, depending on the performance capabilty of the system.

Depending on the density of the area served, several cluster systems may be required in order to stay under the 10,000 gpd limit on flow. In these instances, a cost analysis should be performed to determine if it may be more cost-effective to install a community treatment plant or connect to a larger municipal treatment facility. Costs of cluster systems to consider are the capital cost of the required number of cluster systems, installation of collection systems from individual properties to the cluster treatment unit, and operation and maintenance of the cluster systems, including the treatment unit, SAS, and any pretreatment units at the treatment site or on individual properties.

Cluster Systems with Enhanced Treatment, Resources and Regulations	
Federal	
NSFC	National Small Flows Clearinghouse: http://www.nesc.wvu.edu/nsfc/
State	
DEP	Title 5 Program: http://www.state.ma.us/dep/brp/wwm/t5pubs.htm#it Title 5: Standard Requirements for … On-Site Sewage Treatment and Disposal Systems and for the Transport and Disposal of Septage, 310 CMR 15.00: http://www.state.ma.us/dep/brp/files/310cmr15.pdf Certification of Operators of Wastewater Treatment Facilities, 257 CMR 2.00: http://www.state.ma.us/dep/bwp/iww/files/257cmr2.htm

Community Treatment Plants

Community treatment plants generally are considered for flows in the 10,000 - 150,000 gpd range, and are appropriate in areas where a higher degree of nitrogen removal is required (down to 7 to 10 mg/L total nitrogen) and/or where cluster systems may not be cost-effective. In special circumstances, community treatment plants may be necessary for flows below 10,000 gpd in order to achieve the Class I Ground Water Quality Standards.

Community treatment plants are larger and more complex than cluster systems, and their requirements for management oversight, operation, and maintenance are much more stringent than for cluster or on-site systems. They require at a minimum a chief operator (Grade 3 or higher) and an assistant operator with coverage of at least two hours a day, five days per week.

There is a greater variety in treatment processes available for community treatment plants than for on-site or cluster systems. In many cases, community treatment plants will employ the same treatment systems found in larger municipal treatment plants, such as **activated sludge, rotating biological contactors (RBC),** and **sequencing batch reactors (SBR).** In addition to the plant itself, collection systems will be required to deliver sewage from individual homes or businesses to the community treatment plant. Consideration must also be given to the design and location of disposal systems for these facilities. Options include open sand infiltration beds or subsurface disposal systems.

Community treatment systems provide greater flexibility in treatment options and better performance than cluster systems or on-site systems, but they involve a more complex permitting, siting, and design process. An economic analysis should be performed to see if specific circumstances render them more cost-effective than other options. Performance bonds or some other acceptable arrangement may be required to protect against failure of the process or equipment.

DEP is now updating its *Guidelines for the Design, Construction, Operation and Maintenance of Small Sewage Treatment Facilities with Land Disposal*, last published in 1988. The new Guidelines will be a technical guide for the design, construction, and operation of small wastewater treatment facilities. They also will outline DEP's current regulations, policies, and

standards for facilities that discharge to the ground. Publication is expected during 2003.

The new Guidelines will reflect the following changes:

- Improvements in existing technology as well as technologies not available before.
- Advances in understanding of ground water flow dynamics and the potential for impacts on downstream resources.
- New DEP policies and initiatives, such as the reclaimed water guidelines and the watershed approach, which directly impact the ground water discharge permit program.
- Experience since 1988 in reviewing the design and operation of wastewater treatment facilities, and new insights into what is necessary to construct, operate, and maintain a modern community treatment facility.

The intent of the new Guidelines is to supplement the standards and design criteria found in the New England Interstate Water Pollution Control Commission document, *TR-16: Guides for the Design of Wastewater Treatment Works – 1998 Edition*. TR-16 will continue to be the primary design reference for DEP use. The Guidelines will provide further information and standards, where necessary, given the particular design and construction problems faced in Massachusetts.

DEP's policy is to encourage the use of new and innovative processes and equipment that have been demonstrated to operate satisfactorily and achieve the primary objective of protecting the waters of the Commonwealth. It will not be possible to cover all recently developed collection, treatment, and disposal processes in the new Guidelines. Processes not specifically referenced in the new Guidelines will be reviewed on a case-by-case basis if they meet the following conditions:

- Thoroughly tested as a pilot plant operated for a sufficient time under representative conditions to demonstrate successful performance and
- Demonstrated performance in full-scale comparable installations under competent supervision

Community Treatment Plants, Resources and Regulations

State	
DEP	*Guidelines for the Design, Construction, Operation and Maintenance of Small Sewage Treatment Facilities with Land Disposal*. Contact DEP for a copy of the 1988 Guidelines. Ground Water Quality Standards, 314 CMR 6.0: http://www.state.ma.us/dep/bwp/iww/files/314006.pdf Ground Water Discharge Permit Program, 314 CMR 5.00: http://www.state.ma.us/dep/bwp/iww/files/314005.pdf Certification of Operators of Wastewater Treatment Facilities, 257 CMR 2.00: http://www.state.ma.us/dep/bwp/iww/files/257cmr2.htm
Other	
NEIWPCC	New England Interstate Water Pollution Control Commission: Document *TR-16: Guides for the Design of Wastewater Treatment Works*, 1998 Edition. http://www.neiwpcc.org/publication.html#16

Municipal Treatment Plants and Sewers

The traditional concept of a municipal or **publicly-owned treatment works (POTW)** is one that serves an entire municipality or significant portions of it, with a treatment facility often located remotely from the areas served. These facilities will discharge up to several million gallons per day of treated effluent either to ground water or surface water. In order to transport sewage over greater distances, an extensive collection system employing gravity sewers, vacuum sewers, force mains, or a combination of these options is required.

Large treatment plants are able to meet very stringent nitrogen treatment standards. Larger plants can better assimilate variations in flow and wastewater characteristics. If run properly by a trained professional staff, they provide consistent and reliable results. Data from recently-permitted POTWs in Massachusetts suggest that well-run operations can consistently achieve levels of nitrogen below 5 mg/L, with some plants achieving levels as low as 2-3 mg/L.

Large plants entail significant capital costs. Other cost considerations are operation and maintenance by a full time staff, with a chief operator and assistant rated at Grade 5 or above. Additionally, these facilities require significant land area, which may limit site options or increase costs if land must be purchased. On the other hand, large plants benefit from economies of scale, and depending on specific circumstances, they may be more cost-effective than several cluster systems or community treatment plants.

Large municipal treatment plants present complex planning, design, cost, and siting challenges. More than any of the other wastewater treatment options discussed in this Guidance, they require active community involvement in planning and implementation.

Municipal Treatment Plants and Sewers, Resources and Regulations	
Federal	
EPA	NPDES Regulation: Clean Water Act, Section 402: National Pollutant Discharge Elimination System http://cfpub1.epa.gov/npdes cwa.cfm?program_id=6
State	
DEP	Surface Water Quality Standards, 314 CMR 4.00: http://www.state.ma.us/dep/bwp/iww/files/314cmr4.htm
	Surface Water Discharge Permit Program, 314 CMR 3.00: http://www.state.ma.us/dep/bwp/iww/files/314cmr3.htm
	Ground Water Quality Standards, 314 CMR 6.00: http://www.state.ma.us/dep/bwp/iww/files/314006.pdf
	Ground Water Discharge Permit Program, 314 CMR 5.00: http://www.state.ma.us/dep/bwp/iww/files/314005.pdf
	Certification of Operators of Wastewater Treatment Facilities, 257 CMR 2.00: http://www.state.ma.us/dep/bwp/iww/files/257cmr2.htm

Water Conservation and Reuse

While Massachusetts may be water-rich in comparison to some sections of the United States, there are several parts of the Commonwealth where a combination of rapid population growth and commercial development has significantly lowered water tables and diminished available water resources in **aquifers**, rivers, ponds, and wetlands. Drought conditions over the past few years have exacerbated these conditions. As a result, a number of communities have been forced to implement severe water use restrictions, and in some instances have curtailed the development of new public drinking water supply wells or individual private wells. The rising cost of water and wastewater treatment, coupled with the difficulty of identifying and permitting viable ground water discharge sites, has also created difficult treatment and disposal issues for communities. Water conservation and wastewater reuse are tools that can help communities deal with these problems.

Water Conservation

Water conservation has an indirect, but potentially important, impact on nitrogen loading to estuaries. With the exception of loadings from lawns, golf courses, and agriculture, nutrient loading does not drop with most water conservation efforts, since the amount of pollution discharged does not change.

However, water conservation can significantly improve the health of estuaries and reduce the costs of restoring them. Lower water withdrawals result in increased ground water and surface water flow, particularly in upstream rivers and ponds. The result is less overall stress on ecosystems and more ability to respond to other system upsets. Water conservation also means lower costs for communities, both for drinking water source development and treatment and wastewater treatment and disposal. In some cases, water conservation programs have allowed communities to forego costly construction or expansion projects.

Water Conservation, Resources and Regulations	
Federal	
EPA	Water efficiency programs: http://www.epa.gov/owm/water-efficiency/index.htm
State	
DEP	Water conservation information: http://www.state.ma.us/dep/brp/dws/conserv.htm

Water Reuse

The use of reclaimed water for situations that do not require the advanced quality of potable water can significantly reduce the pressure to develop new potable water sources or to overuse existing sources, as well as provide cost-effective and environmentally sound options for wastewater disposal. Applications such as spray irrigation can also have beneficial impacts on water quality, by allowing vegetation and soils to treat contaminants as the water passes through them.

DEP requires a ground water discharge permit for water reuse. To help communities and property owners use this option, DEP has developed *Interim Guidelines on Reclaimed Water*. The Guidelines include the following requirements in order to protect public health:

- Rigorous water quality criteria: The reclaimed water must be virtually pathogen and contaminant free. The greater the risk of human exposure, the more stringent the standard.
- Demonstrated ability of the wastewater treatment plant to consistently meet effluent standards, and an alternate disposal option that can be employed immediately if reclaimed water criteria are not met.
- Duplicative systems and alternate sources of power for the treatment plant, so that treatment capabilities will not be jeopardized during power outages and repairs.
- Best management practices (BMPs) are aimed at minimizing direct human exposure.
- Advanced monitoring program to determine the effluent quality at the treatment plant and measure impacts on both surface water and ground water.
- Public acceptability: Regardless of the technical and environmental soundness of the reuse program, the public must believe that wastewater reclamation and reuse is a viable approach.

DEP allows the following uses of reclaimed water:

Golf Course and Nursery Irrigation. These are reuse options for the summer months, and require a number of BMPs to minimize direct human exposure.

Toilet Flushing. A dual plumbing system is required in order to prevent public access to the plumbing. Appropriate signage is critical, to inform the public that reclaimed rather than potable water is being used.

Artificial Aquifer Recharge. Reclaimed water discharges into Zone IIs (hydrogeologic zones of contribution to a public water supply well), are allowed if they result in a net environmental improvement within the watershed and do not adversely impact ground water uses in the Zone II. Due to pathogen transport concerns, discharges that would take less than two years to travel to any public water supply are not normally allowed. A discharge may be permitted within the two-year time of travel under exceptional circumstances deemed by DEP to be extraordinary and critical with no other feasible siting alternatives, and provided an advanced level of treatment and monitoring is included.

As knowledge and experience in the use of reclaimed water increases in Massachusetts, DEP may allow other uses. DEP has already received inquiries on using reclaimed water to irrigate ball fields and outdoor areas at office parks and public facilities, as cooling water, and for use in car wash facilities. Several of these uses, e.g., drip irrigation of landscape planting, have already been approved on a pilot basis to determine their feasibility, necessary treatment standards, and operational restrictions. DEP is presently conducting a review of the interim reclaimed water guidance, including the potential addition of new uses and revised treatment standards consistent with national practice. The review will be complete and new guidelines available in the near future.

Water Reuse, Resources and Regulations	
State	
DEP	Interim Guidelines on Reclaimed Water: http://www.state.ma.us/dep/brp/wwm/files/reuse.pdf Ground Water Quality Standards, 314 CMR 6.0: http://www.state.ma.us/dep/bwp/iww/files/314006.pdf Ground Water Discharge Permit Program, 314 CMR 5.00: http://www.state.ma.us/dep/bwp/iww/files/314005.pdf

Management Districts

Management districts are legal, geographic entities established in order to carry out environmental work such as funding and building infrastructure improvements, managing infrastructure or programs, or providing other environmental protection services. This section of the Guidance introduces the concept of management districts, summarizes the legal mechanisms available to establish them, and notes advantages and disadvantages of different district approaches. Appendix G provides more detail on legal mechanisms for establishment of management districts. DEP also plans to develop more comprehensive guidance on management districts for use by municipalities.

Districts are used throughout the United States to protect many different types of environmental resources, but they are less common in Massachusetts given our tradition of strong local government. However, districts have been used here to provide traditional environmental protection and utility services, most commonly for water delivery and wastewater or septage treatment in geographic areas that cross municipal boundaries.

More recently, a few Massachusetts local governments have established districts and management programs to provide non-traditional environmental services or to manage activities that have historically been the responsibility of individual property owners, for example, management of on-site treatment systems, construction and management of decentralized sewers, and operation of stormwater treatment systems. Appendix H lists some of the newer management districts and programs in use in Massachusetts.

Benefits of the District Approach

Districts are an important approach for dealing with nutrient pollution, particularly when a problem is difficult or expensive to address with conventional municipal services or management mechanisms, or where the environmental impact of individual activity requires a higher degree of management. The benefits of management districts are their *focus*, *flexibility*, and *appropriate funding:*

Focus: Districts provide a targeted approach to environmental, resource, or public health issues specific to a certain geographic area. They allow the management clarity and specificity sometimes lacking in the wide spectrum of activities carried out by local governments.

Flexibility: Management districts can be structured and funded differently depending upon the services being provided, the geographic area included, and the available funding. Examples of flexibility include:

- Services for watersheds, lakes, and estuaries whose boundaries cross municipal boundaries.
- Services that differ from those traditionally offered by a municipality, such as management of on-site wastewater systems.
- Services based on regulations and programs of multiple authorities, each with its own set of requirements, performance criteria, and involved parties.
- A comprehensive range of services, or a single service. Districts also have flexibility in providing the services themselves, contracting with other providers, or establishing performance standards that district members must meet.

Funding:

- Districts can be designed to generate fees or levy taxes solely on the individuals benefiting from the services, without increasing costs to other taxpayers.
- Districts can issue bonds and notes and raise revenues to carry out their stated purposes.
- For services traditionally provided by individual property owners, such as on-site wastewater system maintenance, the pooling of services offered by a district can save money for individual homeowners.

Legal Mechanisms to Establish Districts

Many legal factors go into a municipality's decision to form a district and its choice of the legal mechanism to establish the district. Discussions with local officials, legal counsel, and the DEP and EPA are crucial, and it is also important that local bylaws do not substantively conflict or interfere with DEP's regulatory and permitting authority over wastewater facilities and discharges. Input from municipal legal counsel is needed to assess the issues associated with charging a fee for any municipal permitting activities.

Massachusetts law provides three mechanisms to establish districts:

- **General State Law**
- **Special Act of the Legislature**
- **Municipal Home Rule Authority, Bylaws, and Regulations.**

General State Law

Massachusetts General Laws (MGL) have three legal options for the establishment of management districts.

Water Pollution Abatement Districts. Under the Massachusetts Clean Waters Act, DEP is authorized to propose, and in some cases mandate, the establishment of water pollution abatement districts consisting of one or more cities or towns, or designated parts thereof.

A regional water pollution abatement district is an independent entity administered by a district commission, with authority to

- Adopt bylaws and regulations;
- Acquire, dispose of and encumber real and personal property, including acquiring real property by eminent domain;
- Construct, operate, and maintain water pollution abatement facilities; and
- Issue bonds and notes, and raise revenues to carry out the purposes of the district by means of apportioned assessments on the member municipalities.

This mechanism allows communities to work together and with DEP to form a management district without a special act of the Legislature. DEP has the authority to mandate formation of a water pollution abatement district, but has not exercised it to date. DEP can also require such a district to implement a water pollution abatement plan subject to DEP approval.

Independent Water and Sewer Commissions and Intermunicipal Agreements. Massachusetts General Law authorizes municipalities to establish an independent water and sewer commission within the boundaries of a municipality, and to enter into intermunicipal agreements for the purpose of jointly performing a service that a municipality is authorized to do individually or to allow one municipality to perform a service for another.

Regional Health Districts. Massachusetts General Law authorizes two or more municipalities to form a regional health district, which has powers and duties equivalent to those exercised by the **Boards of Health (BoH)** and health departments of the constituent municipalities. The primary purpose of a regional health district does not appear to be pollution abatement, but the language is broad enough to encompass the wastewater regulatory powers of a BoH and, therefore, may be another general law option worth exploring.

Special Act of the Legislature

The Massachusetts Constitution authorizes municipalities to file home rule petitions with the Legislature requesting enactment of a special law. In practice, this is the legal mechanism most often used to establish a region-wide district. A special act may also be necessary or appropriate when a municipality is seeking to manage a service within its boundaries in a manner that goes beyond or is inconsistent with applicable general or special laws.

The municipal legislative body must approve a home rule petition before it can be acted on by the Legislature, although a local vote does not preclude legislative amendments. In addition to involving the municipality's executive, municipal counsel, and state legislator(s) in discussions about home rule petitions, it is also important to consult with EOEA and DEP. Both agencies will typically comment on the merits of the proposed legislation, and their support can be an important factor in securing passage of the bill.

Because of the Legislature's broad authority to enact laws consistent with the state constitution, including the power to exempt municipalities from otherwise applicable general laws, the enactment of special legislation can be the most effective vehicle for establishing a district encompassing more than one municipality, an environmentally important geographic area, or for innovative organization of district activities.

Municipal Home Rule Authority, Bylaws, and Regulations.

The Massachusetts Constitution grants authority to a municipality to exercise any power or function which the Legislature has the power to confer on it and which is not inconsistent with the Constitution or a state law or prohibited by the municipality's charter. Municipalities may adopt zoning or general bylaws to regulate a wide range of uses and activities within all or a portion of their boundaries, although the bylaws must be reviewed and approved by the Commonwealth's Attorney General.

*Zoning Bylaws***.** A zoning bylaw typically imposes restrictions on categories of land uses located in a defined geographical area. For example, it may establish an aquifer protection district that encompasses the boundaries of the Zone II of contribution to a public water supply well and prohibit certain new land uses within that area. However, zoning bylaws must allow the continuation of nonconforming land uses within a zoning district, provided the uses were in place prior to passage of the bylaw. A zoning bylaw requires a planning board hearing and a two-thirds vote of town meeting.

General Bylaws. In contrast, a general bylaw typically applies uniformly to all existing and new uses or activities subject to the bylaw, and requires only a majority vote of town meeting. A common example is a wetlands protection bylaw that implements a local permit program with more stringent requirements than the state Wetlands Protection Act. A general bylaw is not required by state law to grandfather prior nonconforming uses.

Local Boards of Health. It is worth noting that a Board of Health has broad authority to regulate wastewater independently of general municipal bylaws. Boards of Health are authorized to promulgate "reasonable" regulations, including regulations that exceed the minimum requirements of Title 5, provided the BoH makes explicit the local conditions that exist and/or reasons that support more stringent regulation. For this particular type of authority, a BoH regulation can be effective, given its existing jurisdiction in this area, experience, and its significant penalty authority.

Choosing the Appropriate Legal Mechanism

Each of these legal approaches has advantages and disadvantages. Under general state law, the provisions for establishing a water and sewer commission and regional health districts are mechanisms available to establish districts that can have a regional focus and/or independent financing and operating authority. On the other hand, sewer commissions and regional health districts have not yet been used to address the wide range of issues related to nutrient loadings. Water Pollution Abatement Districts can be structured to meet particular local needs, but they have not been used to date.

A special act of the Legislature allows one or more communities to craft a district that meets their particular needs. However, this approach requires close work with a large group of stakeholders. Municipal home rule authority can be used relatively quickly to establish districts, and the local departments administering them are well-known mechanisms. However, districts formed through local bylaws cannot cover more than single municipality and they are dependent on the municipality for their authority and funding mechanisms.

Communities may opt to provide management services through their Board of Health authority because it may be more expedient and because of confusion about what constitutes a management district and its benefits. However, the complexity of watershed-based nutrient management plans and the challenges in managing nutrients from sources such as on-site systems or stormwater are strong arguments in favor of a more formal district structure.

Management Districts, Resources and Regulations

Federal	
EPA	Draft EPA Guidelines for Management of On-site/Decentralized Wastewater Systems, September 2000: http://www.epa.gov/owmitnet/mtb/decent/downloads/guidelines.pdf
State	
Marine Studies Consortium	M.T. Hoover: A Framework for Site Evaluation, Design, and Engineering of On-Site Technologies Within a Management Context, 1997. Executive Summary: http://www.brandeis.edu/marinestudies/risk.html Entire Report: http://www.state.ma.us/dep/brp/wwm/files/hoovered.doc
Pioneer Valley Planning Commission	*How to Create a Stormwater Utility,* 1999. http://www.pvpc.org/docs/landuse/pubs/storm_util.pdf

Land Use Planning and Controls

Land development leads to increased nitrogen loading for several reasons. It increases human population growth and activity, and also reduces the ability of the land to naturally remediate nutrients, by increasing impermeable surface areas, removing vegetation that naturally recycles nitrogen, and destabilizing soils, thereby allowing the release of soil-bound nutrients.

Land use planning does not attempt to stop growth, but does seek to influence its amount, rate, location, and character, in order to maintain the community's long-term viability. Awareness of the issues raised by growth is increasing, and tools have been developed to help communities plan and control the use of land. For example, the Community Preservation Initiative within EOEA focuses on preserving and enhancing the quality of life in Massachusetts communities, including land and watershed protection, affordable housing, historic preservation, economic development, and transportation. It seeks both to balance these interests and also to encourage communities to maintain their unique characteristics and quality of life as they develop.

Smart Growth

Typically, planning for land developments requiring state permits for drinking water sources, wastewater disposal, and stormwater management does not begin with an evaluation of the capacity of the natural resources on the site to accommodate the development. Most often, DEP is involved only in a final and separate stage, to consider the impact of the development on public health and natural resources. A smarter approach to developing sites requiring multiple state permits would minimize the competition between permits and use an integrated approach to evaluate combined resource needs and the impact of the development on issues of watershed quality.

As part of the MEP, DEP is evaluating ways to integrate issues raised by land development with the issuance of environmental permits. The Community Preservation Initiative within EOEA also provides communities with tools and programs to support planning. The **Metropolitan District Commission (MDC)** has published *Growth Management Tools: A Summary for Planning Boards in Massachusetts*, which summarizes a number of options available to local boards.

Open Space Acquisition

Although of limited utility in remediating waterbodies suffering the effects of high nitrogen loads, open space acquisition remains an important option in preventing further degradation by new discharges. Consideration should be given to acquiring or protecting additional open space in places that will support the ecological health of water bodies. For example, communities may maintain areas of open space to prevent further nitrogen loading or to offset more densely developed areas. Purchasing nitrogen loading land use restrictions instead of a fee acquisition may also provide a more cost-effective approach to limiting discharges and nitrogen inputs to the watershed.

Zoning and Related Tools

In addition to state-level permitting, local zoning bylaws remain an important mechanism to promote the type and amount of development compatible with the capacity of local resources. Frequently there is a disconnect between the maximum build-out allowable under zoning bylaws and the capacity of a site to generate and protect sufficient water supplies and also to adequately dispose of wastewater discharges and stormwater runoff.

The Commonwealth's Rivers Protection Act establishes riverfront areas and buffer zones along streams and rivers for which local Conservation Commissions must review activities that may impact on wetland resource areas and water quality. These regulations are helpful to communities seeking to limit nutrient loading from riverfront development, for example, nitrogen and phosphorus loadings from lawn fertilizing.

Land Use Planning and Controls, Resources and Regulations

State	
EOEA	Community Preservation Initiative web site: http://commpres.env.state.ma.us
MDC	*Growth Management Tools: A Summary for Planning Boards in Massachusetts*, August 2002. http://www.state.ma.us/mdc/MDC%20Growth%20Management%20Tools.pdf
DEP	Wetlands Protection Act (WPA): http://www.state.ma.us/dep/brp/ww/files/310cmr10.pdf Rivers Protection Act,1996 amendment to the WPA: http://www.state.ma.us/dep/brp/ww/files/riveract.htm

Nutrient Trading

Nutrient trading is a regulatory tool that allows pollution sources to reallocate responsibilities for pollution reduction among themselves and fund the most cost-effective reduction measures in order to meet regulatory requirements. Following is a brief introduction to watershed-based nitrogen trading, including issues to consider when evaluating this tool. The concepts and issues identified here apply to nitrogen, phosphorus, and other water quality pollutants; however, nitrogen is the pollutant of interest for this Guidance.

Pollution trading has been used extensively in air quality programs in the United States, and watershed-based trading is an emerging tool for communities to consider in meeting nitrogen threshold limits set in TMDLs. EPA promotes the use of effluent trading in watersheds, and has issued a Draft Framework for Watershed-Based Trading to guide communities in its use. EPA proposed a National Water Quality Trading Policy in January 2003.

Trading offers the following benefits to communities as a tool for nitrogen management:

- Cost-effective pollution reduction and flexibility on choice of nitrogen reduction methods, which can provide significant savings to communities. Nitrogen reduction from nonpoint sources is usually much less expensive than from point sources, which makes this type of trading particularly cost-effective.
- Increased incentives to reduce pollution below regulatory limits. If a source voluntarily reduces its pollution load, it can sell these credits to dischargers facing more expensive pollution reduction costs.
- Incentives to develop new and more cost-effective technologies to prevent or reduce pollution and monitor results.
- In some cases, independent watershed groups are allowed to purchase pollutant discharge credits, essentially retiring them. This also leads to an overall improvement in water quality, since it reduces the amount of overall effluent that can be discharged.

Current Massachusetts wastewater regulations do not expressly authorize nutrient trading as a wastewater management tool. However, a small number of treatment plant permits (NPDES and ground water discharge) in the state have included nutrient offsets, which is one form of trading. *(See Appendix I for more information and case studies of nutrient trading in Massachusetts and other states.)*

DEP encourages communities to explore all approaches to nutrient trading in combination with other management tools, using EPA's publications as guidelines. DEP will work with communities to evaluate nutrient trading approaches that meet their needs, and plans to evaluate the role of nitrogen trading tools within Massachusetts wastewater regulations.

Nutrient Trading, Resources and Regulations

Federal	
EPA	Draft framework and other background documents: http://www.epa.gov/owow/watershed/framwork.html
	Office of Water: Final Water Quality Trading Policy, January 13, 2003: http://www.epa.gov/owow/watershed/trading/finalpolicy2003.html
	Environomics: *A Summary of U.S. Effluent Trading and Offset Projects,* November 1999: http://www.environomics.com/Effluent-Trading-Summaries_Environomics.pdf
Other	
	Northbridge Environmental: *Overview of Water Pollution Trading in Massachusetts,* June 2001. Printed copies are available from DEP.
National Wildlife Federation	*A New Tool for Water Quality. Making Watershed-Based Trading Work for You*, June 1999: http://www.nwf.org/watersheds/newtool.html
World Resources Institute (WRI)	*Fertile Ground. Nutrient Trading's Potential to Cost-Effectively Improve Water Quality, 2000* http://www.wri.org/wri/water/nutrient.html WRI web site that tracks trades and provides historical information on past trades: http://www.nutrientnet.org/